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First Constraints on ALP-photon Couplings from Multimessenger Studies of the Neutron Star Merger GW170817

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We use multimessenger observations of the neutron star merger event GW170817 to derive the first merger constraints on axion-like particles (ALPs) coupling to photons. ALP production from Primakoff and photon coalescence processes is calculated; then, the region of parameter space where ALPs can escape the remnant and decay back into two photons is considered. This gives rise to an ALP-induced photon signal approximately along the line-of-sight to the merger event. The spectral and temporal behavior of the ALP-induced photon signal as a function of the ALP mass and coupling is studied, with particular care to the decay geometry which is the main source of the temporal dependence. Fermi-LAT observations of GW170817 in the time window 1153 – 2027 s after the arrival of the GW signal is then employed to impose an upper bound on the ALP-induced photon signal flux, and hence the first merger constraints on the ALP-photon coupling. We then investigate the prospects of future MeV gamma-ray missions to constrain ALPs using a combination of temporal and spectral information. Taking the spectral coverage of AMEGO-X as an example, and assuming that data is obtained concurrently with the GW signal and up to times when the ALP-induced emission diminishes, we show that AMEGO-X will constrain new regions of ALP parameter space.

Author: SINHA, Kuver (University of Oklahoma)

Presenter: SINHA, Kuver (University of Oklahoma)

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